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Effect of Admixtures (Fly Ash and Super Plasticizer) on Performance of Concrete

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***Abstract:** This research is conducted to study the performance of concrete mix containing Class-C Fly ash and P250 super plasticizer. The concrete mix are also proportioned to have various proportion of cement replacements by fly ash ranging from 10% to 30% by weight and super plasticizer PC250 from 0.5% to 1.5% by weight of cement. The performance of concrete is evaluated with respect to workability and compressive strength by Destructive and Non destructive test (rebound number). At 28 day. Concrete mix containing fly ash and super plasticizer shows consistently higher compressive strength compared to concrete with only fly ash and without fly ash. It has been observed that by addition of fly ash the initial compressive strength is lower because of unhydrated cement, since the addition of fly ash lowers the rate of hydration of cement. According to the analysis of results show that class- C fly ash could be substituted for cement replacement, as the concrete with fly ash 30% and super plasticizer shows 34.19% more strength as compared to non fly ash concrete. Similarly increase in workability also observed upto 240mm slump value.*

I. INTRODUCTION

This paper concerns the study of effect of admixtures (Class C Fly Ash & PC 250 Super plasticizer) on performance of concrete. Fly ash meets all the requirements of ASTM(American Society for Testing and Materials) C-618, 'Specifications for fly ash and raw or calcined natural pozzolan for use as a mineral admixture in portland cement concrete,' is used either as a cementitious material or as an Admixture. ASTM C-618 categories fly ash into two classes for the use in concrete mix:

1) *Class F:* It is derived from the burnt product of anthracite or bituminous coal, and
2) *Class C:* It is produced by burning of lignite or sub bituminous coal.

Another classification of fly as as per IS code (**IS:3812-1981**)

a) *Grade-I:* This grade of fly ash is generally derived from Bituminous coal having fraction (SiO_2 + Al_2O_3 + Fe_2O_3) more than 70%.
b) *Grade-II:* This grade of fly ash is derived from Lignite coal having fraction (SiO_2+Al_2O_3+Fe_2O_3) more than 50%

ASTM C-618 also describes requirement for the chemical, mechanical, and physical properties for following two classes of fly ash. Class-F Fly ash is pozzolanic, with no or minute cementing properties itself. While class-C Fly ash has self-cementing property as well as pozzolanic properties. In the modern coal fired power plant, Fly ash is generally collected by Electrostatic Precipitators or any other particle filtration equipment before the Flue gases reach the chimney. The composition of fly ash differs depending on the source of the coal being burned, but fly ash of both type generally contains significant amounts of Silicon Dioxide (SiO_2), Aluminium Oxide (Al_2O_3) and Calcium Oxide (CaO). Fly ash can be used as a partial replacement for cement due to the presence of pozzolanic activities, which are responsible for setting of concrete. It also provides more resistance to the concrete from chemical attack and wet conditions.

Super Plasticizer (SP), also called as water reducer, these are additives which is used in high strength concrete. Super plasticizer can be divided into following types :

- Purified Lignosulfonates,
- Carboxylate Synthetic Polymers,
- Sulfonated Synthetic Polymers, and
- Synthetic polymers

By the use of super plasticizers it is possible to obtain very low water/cement (w/c) ratios while maintaining the required concrete workability. Hence the objective of super plasticizers to find optimum dosage (i.e. dosage volume, dosage time, and their type) on freshly prepared concrete mix. Super plasticizer is most effective water reducer specially when modified by the inclusion of a copolymer. Super plasticizer cause the cement to disperse through the action of repulsion, the Sulphonic acid which is absorbed on the surface of cement grains, make them to mutually repulsive because particle becomes negatively charged. This alsi increases the workability at any given w/c ratio, typically raising the slump from 75mm to 200mm(as per A.M.Neiville)

A. Mechanism of Super Plasticizer

Cement particles develops static electric charge on their surface due to the cement-grinding process. Unlike charge attracts, causing the cement particles to 'cluster' or 'flocculate', which in turns limit the workability. While super plasticizer has both positive as well as negative charge. Hence these molecules are attracted by charged surface of the cement particles. The super plasticizer neutralize the static attraction action on the cement surfaces. As a result, the flocculates of cement particles are broken apart. Due to mutual repulsion of like charge particles pushes the cement grains apart results a better distribution of particles, more uniform hydration, and less viscous paste.(according to Frederick S. Merritt and Jonathan T. Ricketts Editor). Super plasticizers can be used when:

1) A low water/cement ratio is required (e.g., early strength gain, high-strength concrete, and to reduced porosity),
2) Placing between thin sections,
3) The concrete is placed around tightly spaced reinforcements,
4) using cement underwater
5) concrete placed by pumping

Table-1 : Chemical Composition of cement

Composition (in %)

Loss on ignition	Alumina Iron ratio	Insoluble residue	Na2O (as Alkalinity)	Cl-	Mg(OH)2	SO3
1.38	1.07	2.20	0.41	0.01	1.11	2.33

II. MATERIALS

A. Cement

The grade of cement used OPC43. All physical and chemical properties of cement were according to IS269:1976. The chemical compositions is given in Table 1.The physical properties of the cement used as listed in table below.

Table-2: Properties of Ordinary Portland Cement

Properties	Test results
Percentage fineness	3.66%
Consistency (%)	30%
Specific gravity	3.21
Initial Setting Time	29min.
Final Setting Time	580min

B. Fine Aggregate

The sand used was locally available and passed through 4.75 mm IS-sieve was used as fine aggregate. The properties of the fine aggregate are listed in the table below.

Table-3: Properties of Fine aggregate

Properties	Test Values
Specific Gravity	2.6
Fineness Modulus	2.674
Water Absorption	1.2%

C. Coarse Aggregate

The coarse aggregate with maximum size as 20mm (67%) and 10mm (33%), as per Indian standards. The properties of coarse aggregate are listed in the table 4.

Table-4: Properties of Coarse Aggregate

Properties	Test results
Specific Gravity	2.67
Fineness Modulus	6.2
Water Absorption	1%

D. Fly ash

The fly ash used in experiment is of class C with specific gravity 2.4. Replacement of cement with fly ash as 10%, 20% and 30% by weight

E. Super plasticizer

The super plasticizer used was of latest generation PC250. The dosage used as 0.5%, 1%, 1.5% by weight of cement.

F. Water

The water used had pH value of 7.3. The water is potable water.

III. TEST ON CONCRETE MIXES

The grade of concrete prepared is of M25. The testing methodology used in this research is based on the Indian Standard and specification. The procedure to determine the workability is according to IS code 1199-1959. The compressive strength test (Based on IS 516-1959) specimens is of size 150mmX150mm per mix for various ages.

A control mix 1 (called as CM1) was casted (with water–cement ratio as 0.4) without any admixture for comparing the workability and strength with concrete mix 2 with only fly ash (while keeping the water cement ratio as 0.45) called as CM2, with replacement of cement by 10%, 20%, and 30%by weight and study the effect of fly ash on strength and workability.

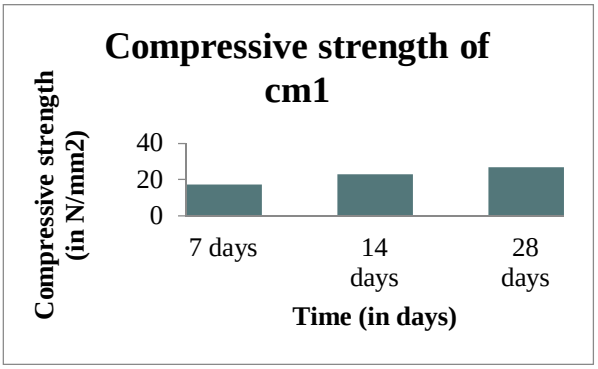

Fig.1 Compressive strength of control mix1

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The replacement of cement with fly ash by 10% by weight called as FA10, similarly 20% replacement called FA20 and 30% replacement called FA30.

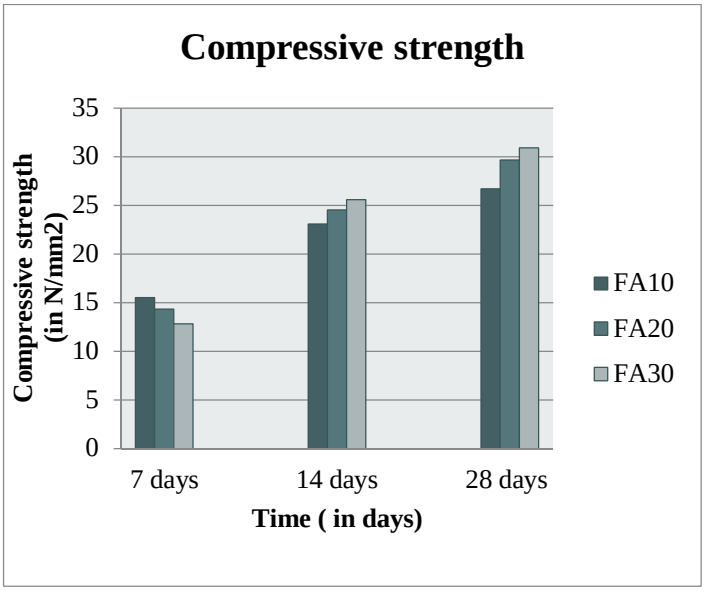

Fig.2 Compressive strength of control mix 2

From the experiment it was observed that the compressive strength of concrete decreases 7% - 8% by adding 10% fly ash initially but after 14 and 28 days it increases uptp 10.64% and 15.93% respectively. It is also observed that while keeping the water cement ratio constant, as the amount of fly ash increase its workability also increases as the data is show in the form of bar graph below.

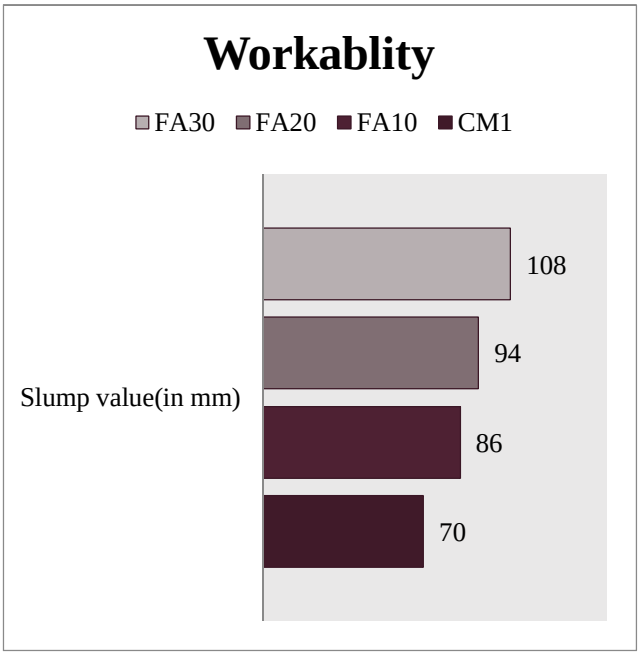

Fig.3 workability of CM1 and CM2

A. Non Destructive Test

The evaluation of the cube specimens by non destructive test(Rebound hammer test) also done for better understanding..

Non Destructive Test (NDT) generally done for evaluating existing structures based on compressive strength, resistivity and many other parameters. As the name suggests the test doesn't damage the structure or the damage is very less compared to destructive tests. Hence it eventually saves the cost. The NDT performed is Rebound hammer test. Rebound hammer test measures the compressive strength of the structure without damaging it.

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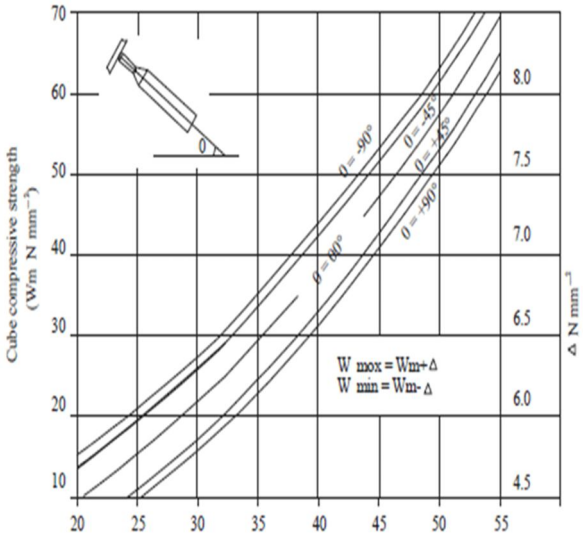
The test results depends upon many conditions such surface roughness and moisture in the structure, so before performing the test it had make sure that the surface is plain and smooth and dried the sample for minimum 5 to 6 hours(as per Dr. V. JAYAKUMAR and Dr.K. Elongovan). The result of rebound hammer test is in form of rebound number and corresponding to it compressive strength is shown in table below.

Table-5: Rebound hammer test result

	Rebound Number		
	7 days	14 days	28 days
CM1	26.44	32.67	35.11
FA10	26.11	33.22	37
FA20	25.21	35.6	37.7
FA30	17.44	37.3	39

From rebound number and compressive strength graph the compressive strength can be calculated. The test was performed at 90 degree.



Graph 1: Compressive strength v/s rebound number

From the rebound number and compressive strength graph, the corresponding compressive strength is calculated and shown in the table below.

Table-6: Compressive strength (Mpa) corresponding to rebound number

	7 days	14 days	28 days
CM1	16.9	22	25.4
FA10	16.3	22.33	27
FA20	16	23	27.8
FA30	---	24.33	28.22

From the above data the compressive strength of FA30 at 7 days cannot be calculates since the relation between the rebound number and compressive strength starts with rebound value of 25 and below 25 the compressive cannot be calculated.

B. Concrete Mix And Proportioning Of Admixtures

The concrete mix contains fly ash and super plasticizer with different proportions as given below table.

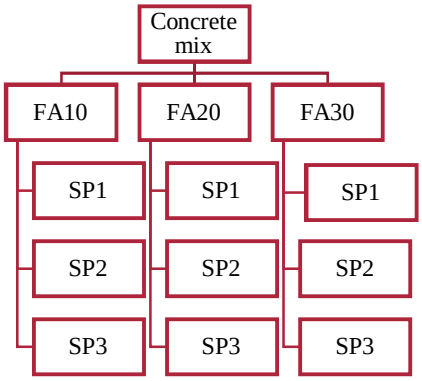


Fig.4: Concrete Proportioning.

The concrete has replacement of cement by fly ash by 10%, 20% and 30% called as FA10, FA20 and FA30 respectively. In addition to that further addition of super plasticizer dosage as 0.5%, 1% and 1.5% in each mix of FA10, FA20 and FA30 respectively, to get the optimum percentage of fly ash and super plasticizer dosage. Hence the mix FA10 has three variant of super plasticizer dosage as 0.5%, 1% and 1.5% called as FA10SP1, FA10SP2 and FA10SP3 respectively. Similarly for FA20 as FA20SP1, FA20SP2 and FA20SP3 and FA30 as FA30SP1, FA10SP2 and FA30SP3.

IV. RESULT AND DISCUSSION

Each set of 3 cubes of (FA10SP1, FA10SP2 and FA10SP3), (FA20SP1, FA20SP2 and FA20SP3), (FA30SP1, FA10SP2 and FA30SP3) concrete were tested in compression testing machine after 7, 14 and 28 days of curing. Three reading were taken and the average compressive strength of concrete is given below:

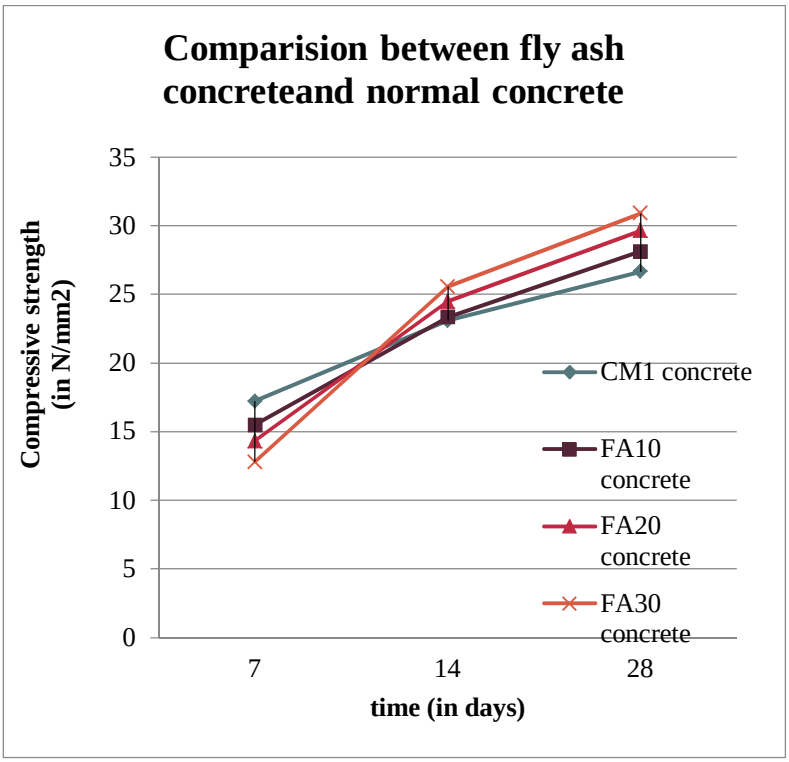


Table 7 : concrete characteristics

Material and Properties	FA10SP1	FA10SP2	FA10SP3	FA20SP1	FA20SP2	FA20SP3	FA30SP1	FA30SP2	FA30SP3
Cement (in kg)	1.683	1.683	1.683	1.496	1.496	1.496	1.309	1.309	1.309
Fly ash (in kg)	0.187	0.187	0.187	0.374	0.374	0.374	0.561	0.561	0.561
Sand (in kg)	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26	2.26
Aggregate (in kg)	3.875	3.875	3.875	3.875	3.875	3.875	3.875	3.875	3.875
w/c ratio	0.45	0.40	0.35	0.45	0.40	0.35	0.45	0.40	0.35
Super Plasticizer (5%)	0.5%	1%	1.5%	0.5%	1%	1.5%	0.5%	1%	1.5%
Slump (mm)	160	170	200	100	180	220	120	150	240

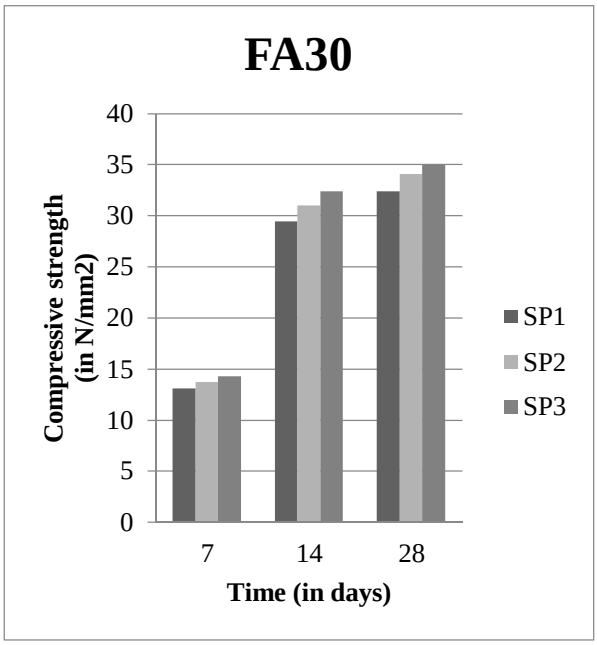


Fig.5: Compressive strength of FA30 with super plasticizer SP1, SP2, SP3 dosage.

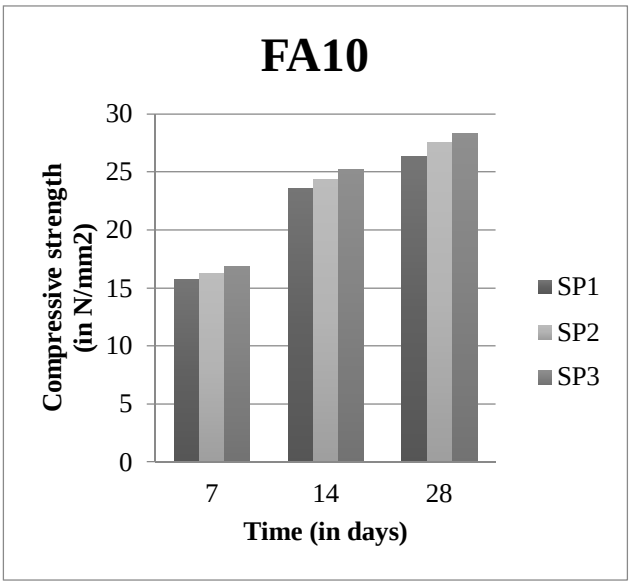


Fig.6: Compressive strength of FA10 with super plasticizer SP1, SP2, SP3 dosage.

Table-8: Result of NDT(rebound hammer test) as corresponding compressive strength

	7 Days	14 Days	28 Days
Specimen name	Compressive strength	Compressive strength	Compressive strength
FA10SP1	15.75	23.64	26.004
FA10SP2	16.275	24.41	26.853
FA10SP3	16.585	24.875	27.365
FA20SP1	14.3	26.1	28.71
FA20SP2	15.25	27.45	30.195
FA20SP3	15.515	27.972	30.719
FA30SP1	13.1	29.475	32.4225
FA30SP2	13.75	30.94	34.04
FA30SP3	14.1	31.52	34.674

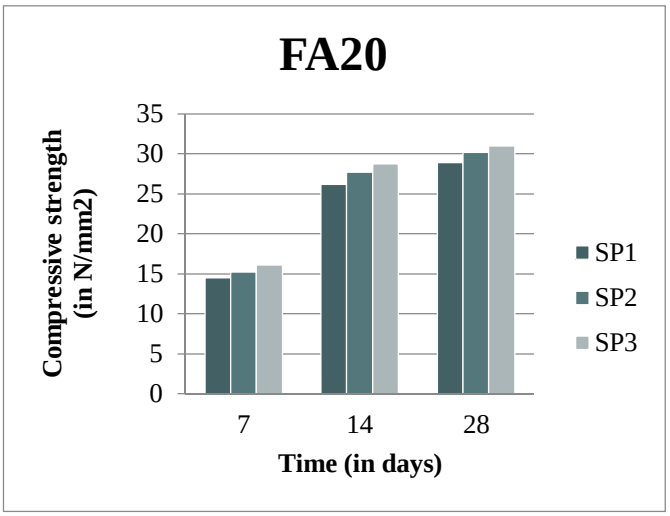


Fig.7: Compressive strength of FA20 with super plasticizer SP1, SP2, SP3 dosage

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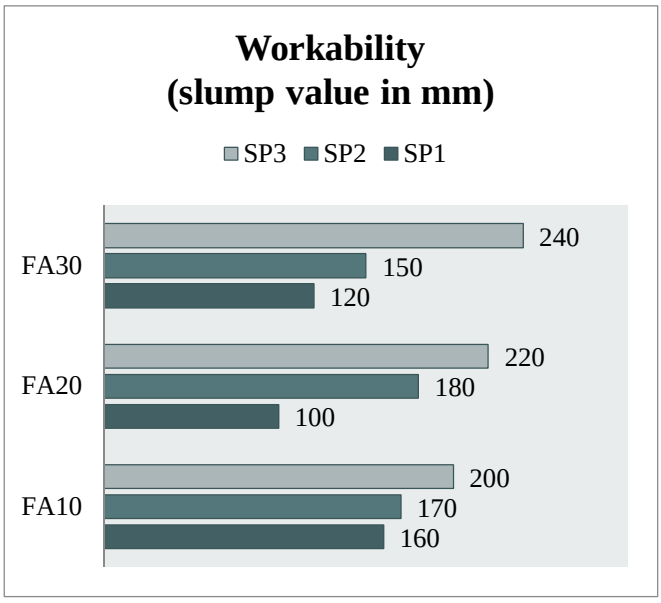

Fig.8: Workability of specimens

Based on the experiment performed for M25 grade of concrete by partial replacement of cement with 10%, 20% and 30% of fly ash and dosage of super plasticizer by 0.5%, 1% and 1.5%. The following were the conclusion:

1) The compressive strength of concrete increases as increase in the fly ash content. The increase in compressive strength of concrete at 28 days was found to be 7.69% more than normal mix in case of FA10SP3. Similarly there is also increase in FA20 as 15.78% and FA30 with SP3 as 34.19%.

2) It is observed that as cement was replaced with fly ash, there is reduction in compressive strength of concrete at 7 days as compared to non fly ash concrete. This is because the secondary hydration is slower at initial stages.

3) The workability of the concrete mix increase with the increase in fly ash.

4) The fly ash particles are finer than the cement particles which increase the consistency as consistency is property which is depends on the fineness of particle.

5) The initial setting time was also increased as the fly ash percentage increase. As per IS456:2000 the compressive strength of concrete with no fly ash have 67% characteristic compressive strength, but from the experiment it has been observed that compressive strength of concrete mix with fly ash content 30% at 7 days was approximately 60% of characteristic compressive strength. Replacement of cement with fly ash can reduce the heat of hydration of concrete. Although this reduction in the heat of hydration does not affect long-term strength gaining or durability.

6) From the results and analysis, it can be concluded that fly ash can be used as replacement of cement but upto certain limits because of the initial less strength, but after 28 days strength can be increased upto 34.19%.

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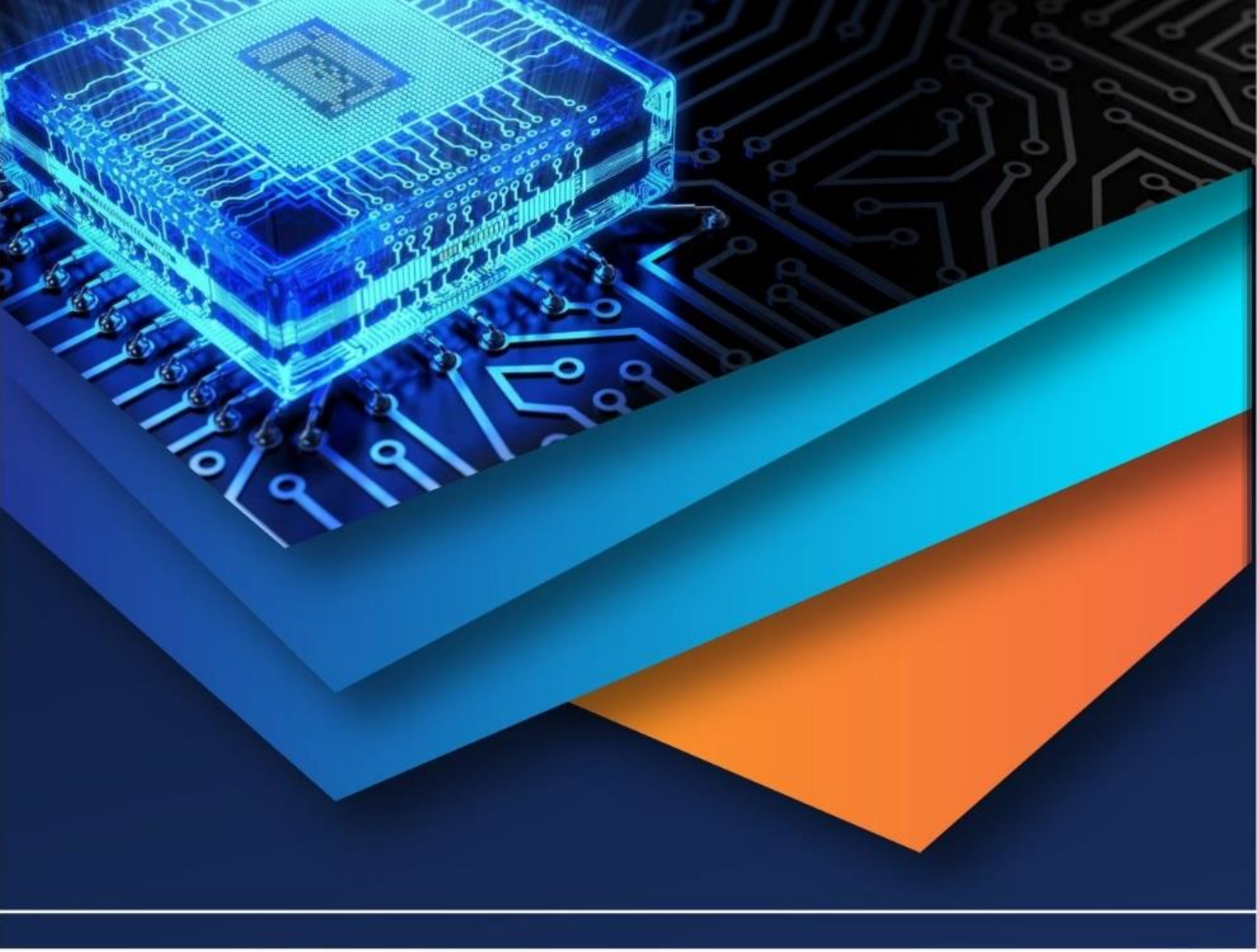

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